BELL WORK
7-Mar-2016

What are a, b, and c asking you to find?

1. A 100 g sample of steam at 150^{o}C is cooled to ice at –15^{o}C.

a. What is the change in heat going from 150^{o}C to 100^{o}C for steam? (5points)

b. The amount of heat lost when steam is converted to liquid water is what? (5points)

c. The total change in heat content when the sample goes to –15^{o}C. (5points)

Agenda

Gases and thermodynamics

Computer simulation

Objective

To explore how gases are affected by different variables using a computer simulation

Computer simulation

- From class web page in lab sections open "**PhET Gas Laws Simulation**"
- Launch the simulation

  URL:

  http://phet.colorado.edu/en/simulation/gas-properties

-OR-

- Google: "gas law PhET simulation"

Before you answering questions…

That you can…

1. Add both heavy and light gases to the container

2. Adjust the temperature of the container while holding the pressure constant

3. Decrease the volume of the container

BELL WORK 8-Mar-2016

Draw three different balloons with air particles in them

1. **One full of gas at room temperature**
2. **One full of gas at 0 °C (~32 ° F)**
3. **One full of gas at 50 °C (~122 ° F)**

Using dots show where the particles are located inside each of the balloons

Use arrows on the particles to indicate how fast they are moving (longer arrow = faster)

Rank the balloons from lowest to highest pressure

Agenda

Gas properties and the KMT

Objective(s)

To identify the properties of gases

To explain properties of gases using the kinetic molecular theory

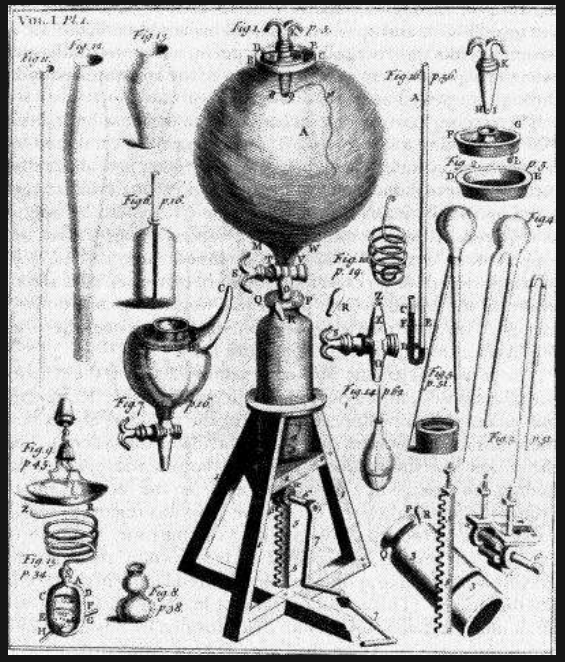
To explain real world phenomena using the kinetic molecular theory and the properties of gases

Demo

Write on your bellwork what you predict is going to happen

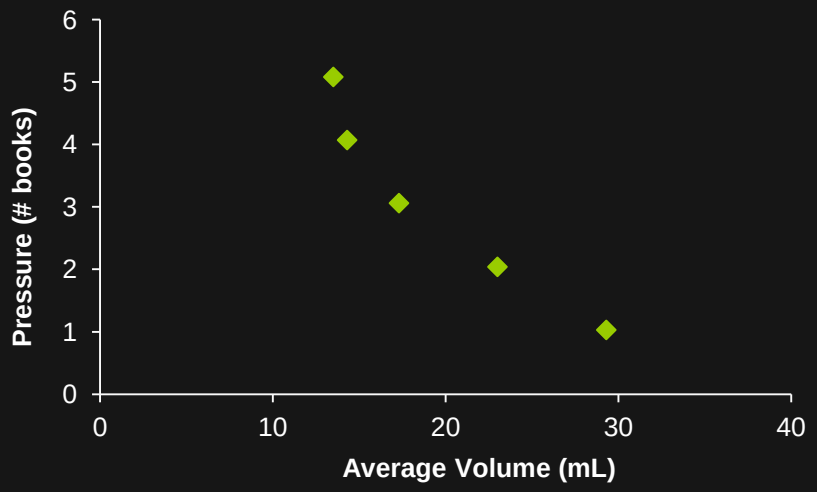
Write down what you actually observed

Boyle's Law

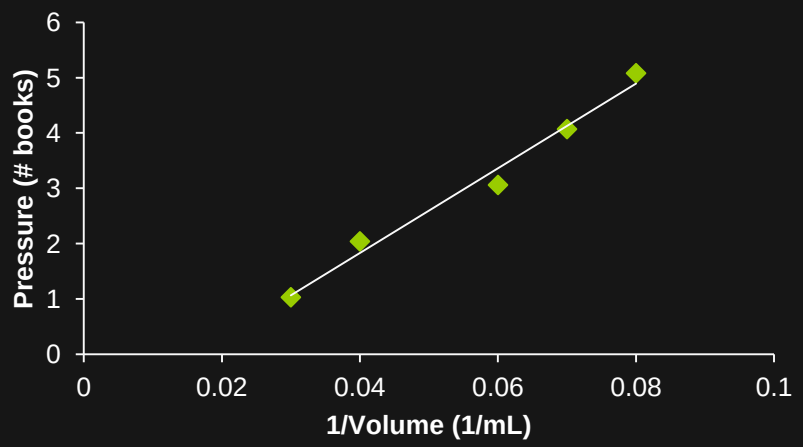


Boyle's Lab Data Analysis

Volume v. Pressure



1/Volume v. Pressure



Boyle's Law

In a system in which the amount of gas in a system stays the same and the temperature remains constant:

$$P_1V_1 = P_2V_2$$

P1 and P2 must be in the same units

V1 and V2 must be in the same units

BELL WORK 9-Mar-2016

What is the relationship between pressure and volume if temperature and moles are held constant?

4.35 L of a gas is at 1.16 atm. What pressure is obtained when the volume is 9.3 L?

<table>
<tr><td colspan="2">1. What you want?</td></tr>
<tr><td>2. Given Information</td><td>4. Plan</td></tr>
<tr><td rowspan="2">3. Useful formulas/ conversions</td><td>5. Calculations for solutions</td></tr>
</table>

Agenda

Gas properties and the KMT

Objective(s)

To identify the properties of gases

To explain properties of gases using the kinetic molecular theory

To explain real world phenomena using the kinetic molecular theory and the properties of gases

Properties of Gases

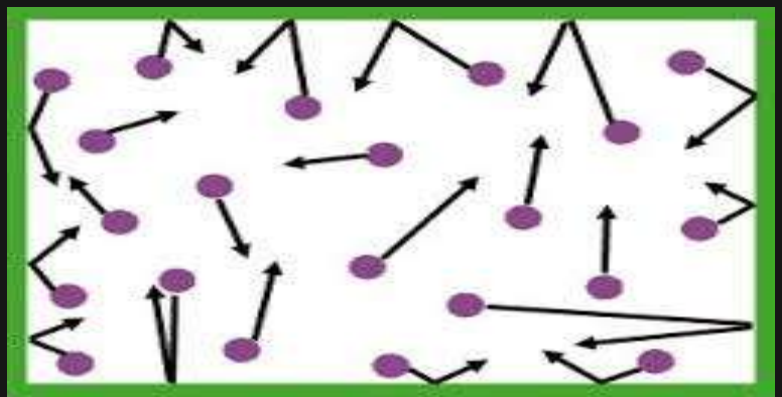
1. Gases assume the volume and shape of their containers.
2. **Gases are the most compressible state of matter.**
3. Gases will mix evenly and completely when confined to the same container.
4. **Gases have much lower densities than liquids and solids.**

Kinetic Molecular Theory (KMT)

Used to explain the behavior of gases

Kinetic Molecular Theory (KMT)

1. Gases are composed of particles moving in constant, random motion
2. Particles in a gas move in a straight line until colliding with another particle
3. The space between gas particles is much greater than that of solids or liquids

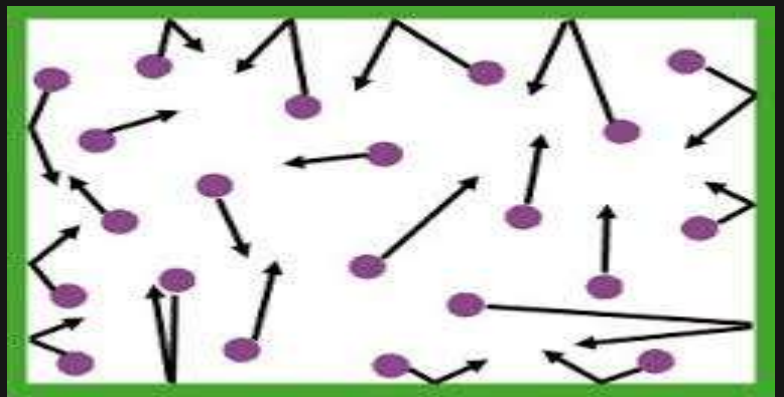


Kinetic Molecular Theory (KMT)

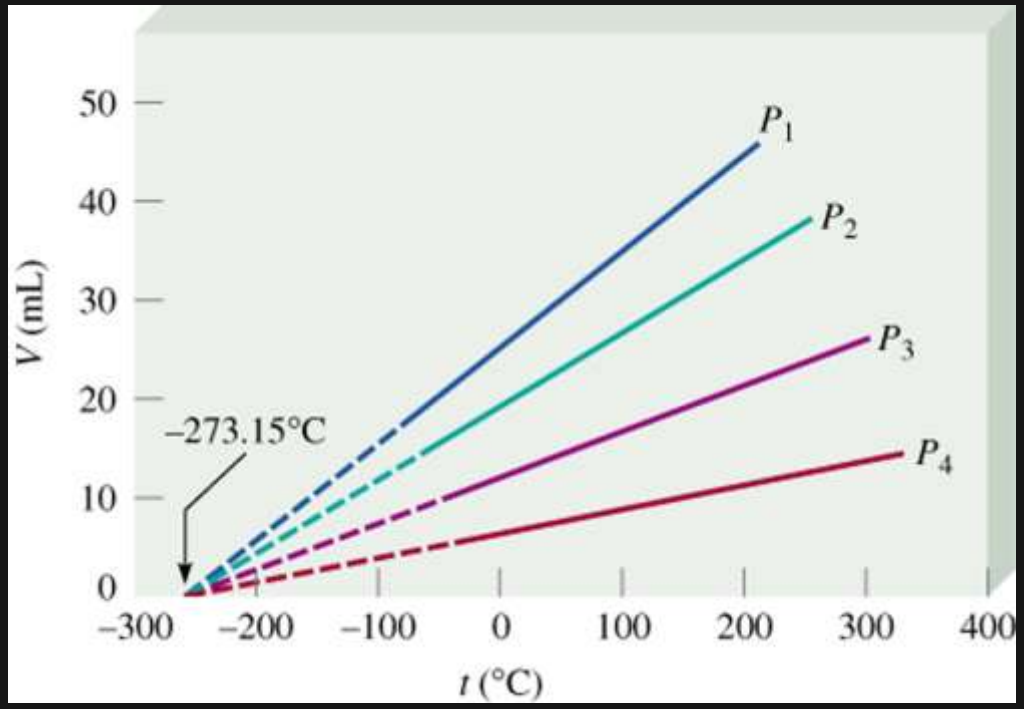
4. The attraction between gas particles is negligible

5. Energy is conserved when particles of a gas collide

6. The average kinetic energy of a collection of gas particles depends on the temperature of the gas



Homework Questions?



Charles' Law

$$V \propto T$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\text{\% Error} = \left| \frac{\text{Theoretical Value} - \text{Experimental Value}}{\text{Theoretical Value}} \right| \times 100$$

All temperature must be converted to Kelvin

To convert $^0C \rightarrow K$

$T\ (K) = t\ (^0C) + 273$

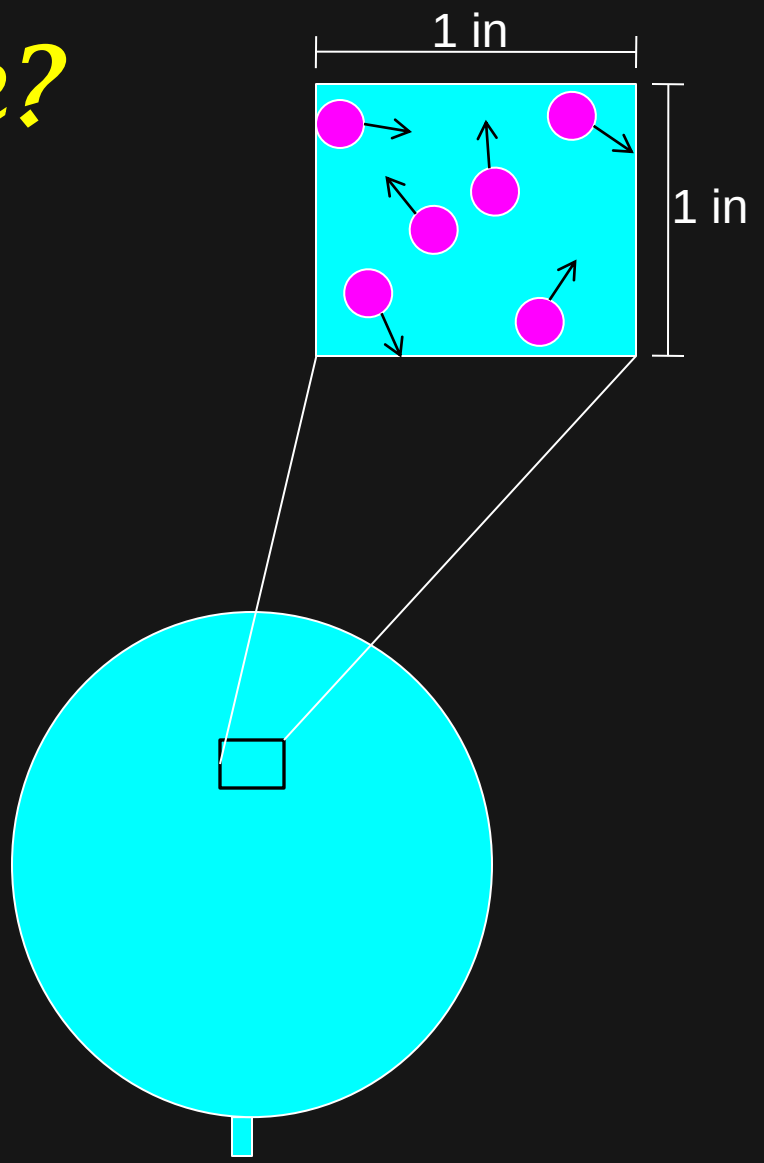
To convert $K \rightarrow {}^0C$

$T\ (^0C) = t\ (K) - 273$

Why is the Kelvin scale used exclusively in gas law calculations?

What is pressure?

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$



Units of Pressure

1 pascal (Pa) =

1 N/m^2 =

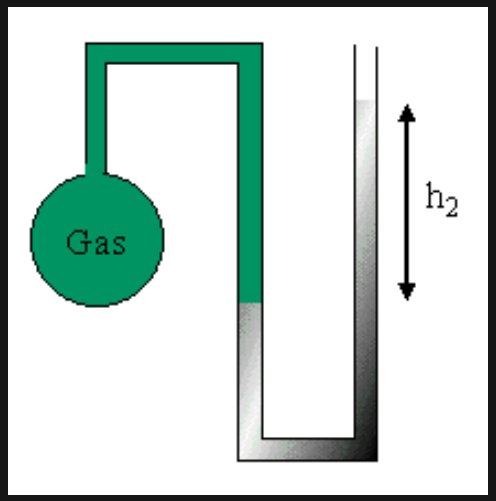
1atm =

760 mmHg =

760 torr =

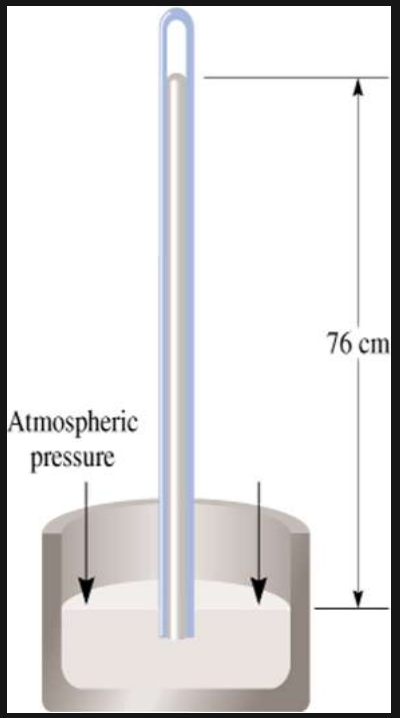
101.325 kPa

How do we measure pressure?



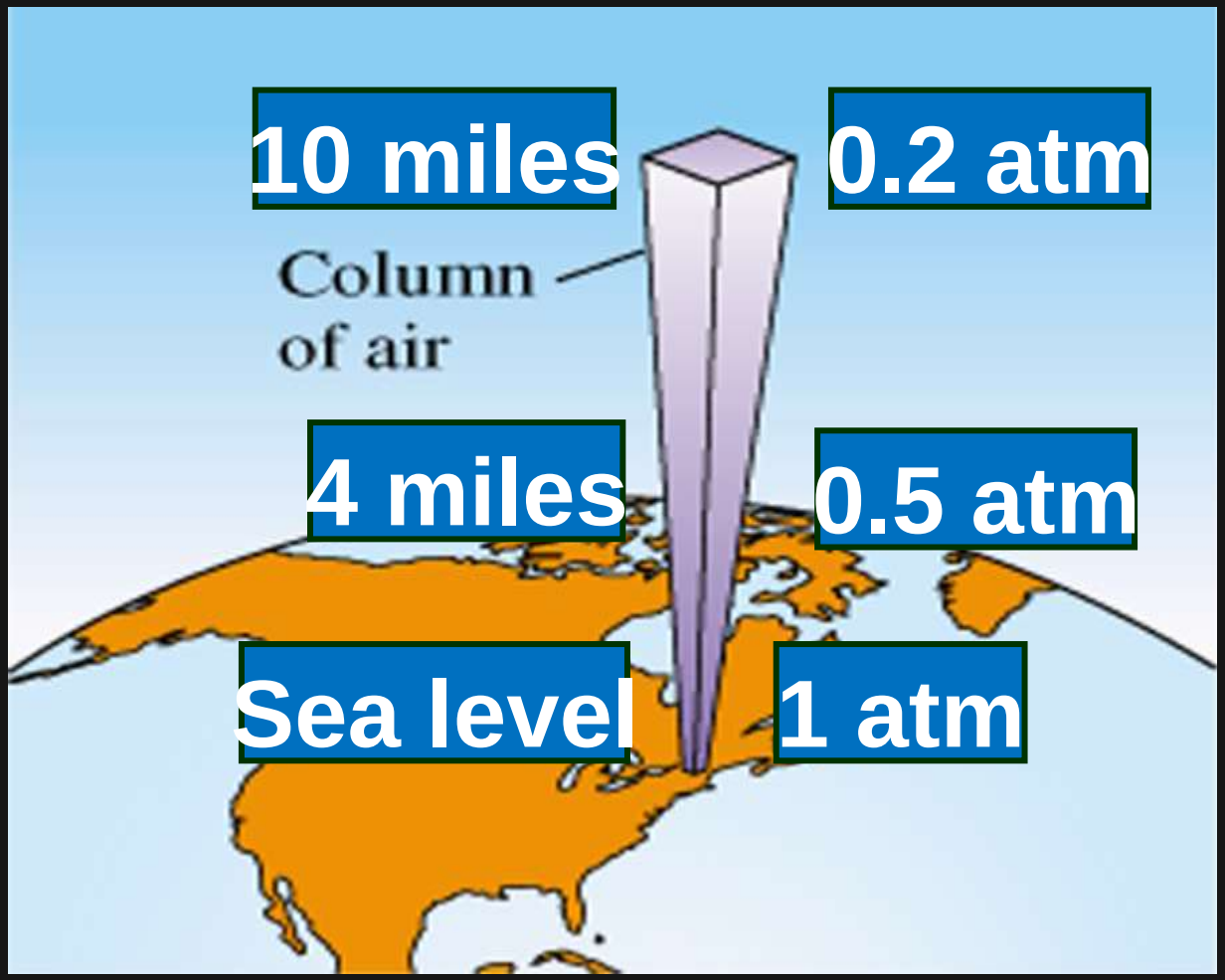
A manometer uses a U-shaped tube of liquid to measure pressure differences on either side of the liquid

A barometer uses the height of a column of mercury to measure gas pressure in mmHg



https://www.youtube.com/watch?v=EkDhlzA-lwI

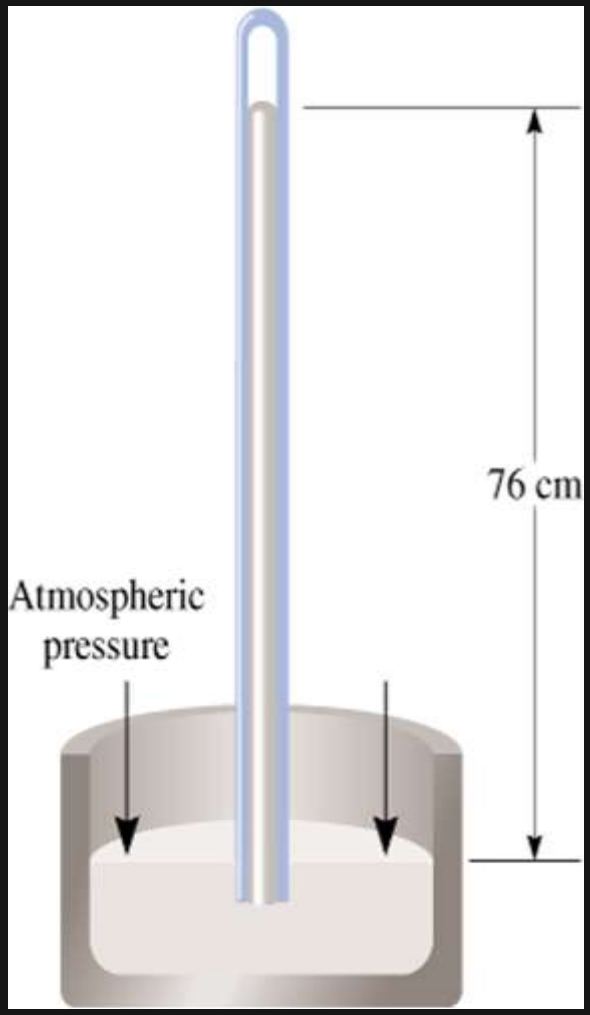
What is the pressure in mmHg at sea level?
What is the pressure in Pascals at sea level?



Try this…

Convert:

1. **727 mmHg into kPa**
2. **52.5 kPa into atm**
3. **0.729 atm into mmHg**
4. **522 torr into kPa**
5. **800.0 mmHg into atm**
6. **495Pa into mmHg**



Barometer

Standard Temperature and Pressure

Standard temperature and pressure **(STP)** refers to nominal conditions in the atmosphere at sea level. This value is important to physicists, chemists, engineers, pilots and navigators. Why?

Temperature = 0° C or 273K
Pressure = 1atm

Now Try This

At STP a sample of nitrogen takes up a volume of 50L. What is the new volume if the pressure is changed to 220 mmHg.

Elements that exist as gases at 25^0C and 1 atmosphere

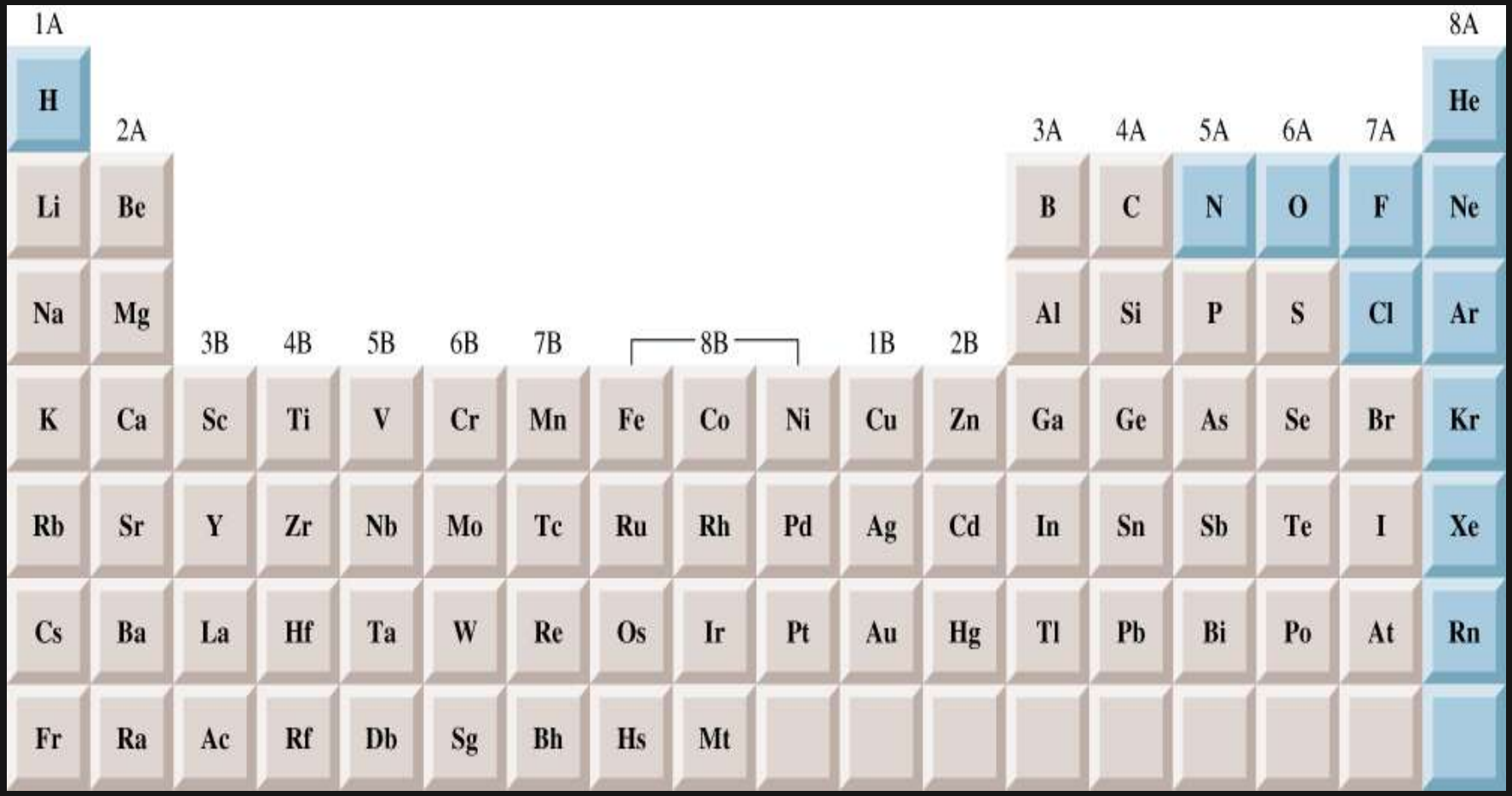


Table 5.1 Some Substances Found as Gases at 1 atm and 25°C

Elements	Compounds
H_2 (molecular hydrogen)	HF (hydrogen fluoride)
N_2 (molecular nitrogen)	HCl (hydrogen chloride)
O_2 (molecular oxygen)	HBr (hydrogen bromide)
O_3 (ozone)	HI (hydrogen iodide)
F_2 (molecular fluorine)	CO (carbon monoxide)
Cl_2 (molecular chlorine)	CO_2 (carbon dioxide)
He (helium)	NH_3 (ammonia)
Ne (neon)	NO (nitric oxide)
Ar (argon)	NO_2 (nitrogen dioxide)
Kr (krypton)	N_2O (nitrous oxide)
Xe (xenon)	SO_2 (sulfur dioxide)
Rn (radon)	H_2S (hydrogen sulfide)
	HCN (hydrogen cyanide)*

** The boiling point of HCN is 26°C, but it is close enough to qualify as a gas at ordinary atmospheric conditions.*

ACTIVITY!

- Two (2) sets of eight stations
- Two (2) people per station at a time
- One (1) prompt per station
- Three (3) minutes per prompt
- Individual answer sheets on a separate piece of paper

ACTIVITY!

For each situation explain:

1. **What gas properties are being observed (use your notes)**

2. **How do you explain these properties using the KMT (use your notes)**

3. **Give another example in which you observe the same situation**

Exit Slip

1. **List the six postulates of the Kinetic Molecular Theory.**

2. **State which one you see at play most in your every day life and give an example of how you see it.**

Bellwork 02/16/15

5L of H_2 gas is at a pressure of 877 mmHg:

1. What is the pressure of the gas in Pascals?
2. If the volume were increased to18L what would the new pressure be in atm?
3. How would the original pressure be different if the gas used was SF_6 instead of hydrogen? Why?

https://www.youtube.com/watch?v=1PJTq2xQiQ0

Recall

1. Octane (gas) reacts with oxygen to form $CO_2(g)$ and water vapor (see below). If 3,000 g of octane is burned how much CO2 is formed during the reaction?

1. Solve Boyle's law for P2
2. A sample of chlorine gas occupies a volume of 946mL at a pressure of 726mmHg. What is the pressure of the gas (in mmHg) if the volume is decreased to 154 mL?

Charle's Law Lab

(at least) Four data points:

1. **One at room temperature (record the temperature)**
2. **One using 600 mL of the ice water in the cooler (make sure not to grab any ice)**
3. **One using 300mL ice water and 300 mL tap water**
4. **On at least <u>ten degrees higher</u> than room temperature (*beginning warming water as soon as you get to your lab*)**

****Do more if you have time**

Bellwork 14 Mar 16

On a spring break trip to the lake you attempt to blow up a beach ball when the temp. was at 15°C. Half way through you gave up leaving the beach ball at a volume of only 3.0L. Later in the day you return to when the temp. was at 30°C, what happened to the volume of your beach ball assuming pressure and mole remain constant?

a. Describe what happened using the KMT and properties of gases *and* do the calculation.

b. What would be the diameter of the beach ball at the 30°C temperature?

c. If the ball weighted 78g and the air in side at 30°C weighted 3.77 what is the density if the air (gas) in g/L?

Agenda

Dalton's Law of Partial Pressures

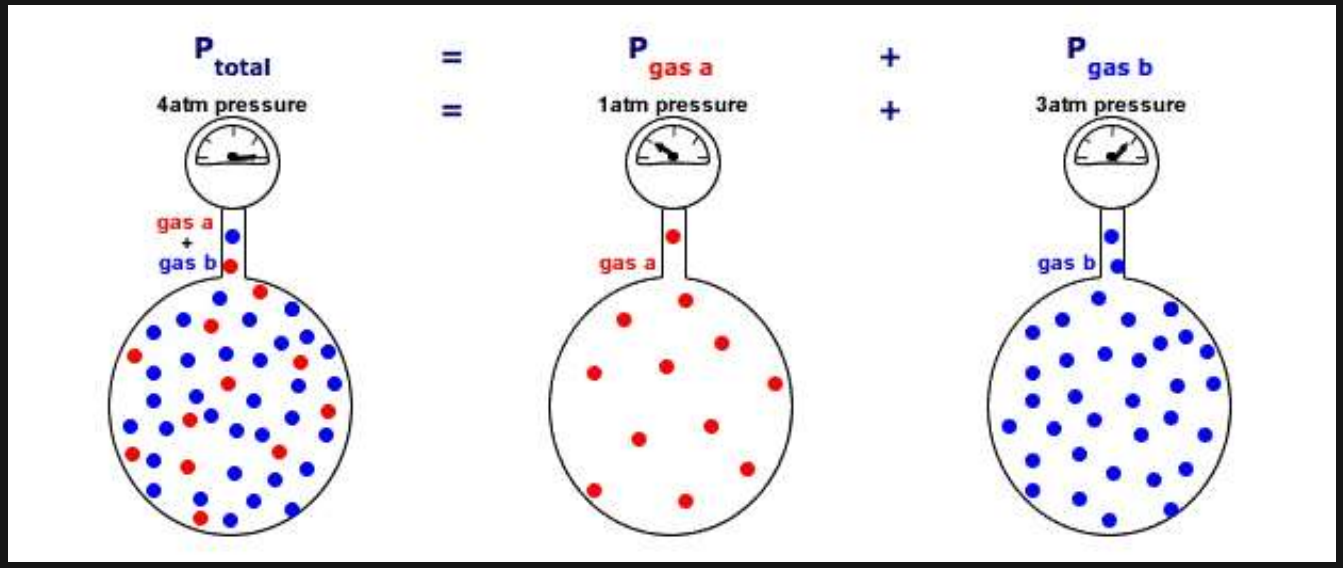
Combined Gas Law/Problem solving box

Objectives

- You will understand Dalton's Law of Partial Pressures and be able to apply it to calculations
- You will be able to determine which equation to use given a word problem.

Dalton's Law of Partial Pressures

At a constant volume and temperature the total pressure exerted by a <u>mixture</u> of gases is equal to the <u>sum</u> of their individual pressures



$$P_{total} = P_1 + P_2 + P_3 \ldots P_n$$

Try This

The air around us contains oxygen, nitrogen, carbon dioxide, and trace amounts of other gases. What is the partial pressure of oxygen at 101.3 kPa of pressure if P_{N2} = 79.1 kPa, P_{CO2} = 0.04 kPa, and P_{others} = 0.94 kPa?

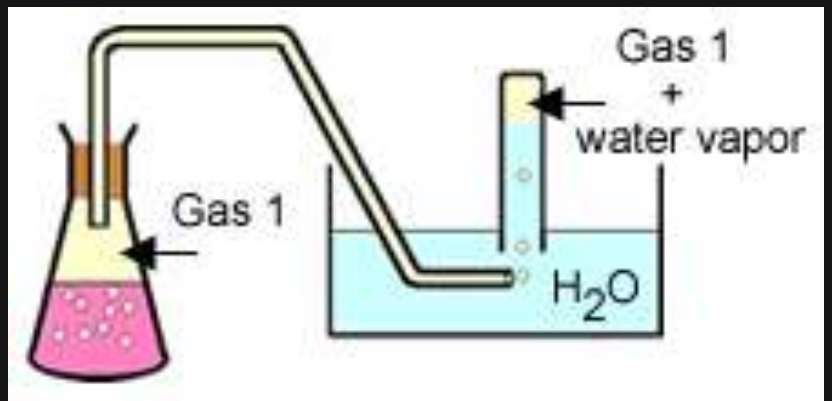
Dalton's Law of Partial Pressures

When collecting a gas over water you need to account for the "Vapor pressure" of water at the collection temperature.

To find the pressure of the dry gas alone, we need to subtract out the pressure of the water vapor.

$$P_{total} = P_{dry\ gas} + P_{water\ vapor}$$

$$P_{dry\ gas} = P_{total} - P_{water\ vapor}$$



Water Vapor Pressure (torr)							
T(°C)	*P*	*T*(°C)	*P*	*T*(°C)	*P*	*T*(°C)	*P*
0	4.58	21	18.65	35	42.2	92	567.0
5	6.54	22	19.83	40	55.3	94	610.9
10	9.21	23	21.07	45	71.9	96	657.6
12	10.52	24	22.38	50	92.5	98	707.3
14	11.99	25	23.76	55	118.0	100	760.0
16	13.63	26	25.21	60	149.4	102	815.9
17	14.53	27	26.74	65	187.5	104	875.1
18	15.48	28	28.35	70	233.7	106	937.9
19	16.48	29	30.04	80	355.1	108	1004.4
20	17.54	30	31.82	90	525.8	110	1074.6

Dalton's Law of Partial Pressures

A sample of H_2 gas is collected over water at 14.0°C, vapor pressure of H_20 at 14°C is1.6kPa. The pressure of the resultant mixture is 113.0kPa. What is the pressure that is exerted by the dry H_2 alone?

$P_{dry\ gas}$ = ?
P_{total} = 113.0 kPa
$P_{water\ vapor}$ = 1.6 kPa

$P_{dry\ gas} = P_{total} - P_{water\ vapor}$

$P_{H2} = 113.0\ kPa - 1.6\ kPa$

Demo

What do we know so far?

With a constant amount of particles in a sample of gas…

Boyles law

$$P_1 \times V_1 = P_2 \times V_2$$

Charles law

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Gay-Lussac's Law

$$\frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Avogadro's Law

$$\frac{V_1}{n_1} = \frac{V_2}{n_2}$$

How can we put it all together to determine relationships between all three?

Combined Gas Law!

When the number of gas particles in the system remains constant:

$$\frac{P_1 \times V_1}{T_1} = \frac{P_2 \times V_2}{T_2}$$

Rearrange the equation for:

1. **T1**
2. **P2**

Word Problem Solving Box

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Word Problem Solving Box

Deep sea divers have to use a mixture of gases at depth in order to avoid sickness. If a tank contains 1.60atm of O_2, 0.5atm of He and 2.9atm of N_2, what is the total pressure of the tank?

1. What you want? **P_{total}**	
2. Given Information **P_{O2} = 1.6atm** **P_{He} = 0.5atm** **P_{N2} = 2.9atm**	4. Plan: **Use Daltons law to solve for P_{total}** 5. Calculations for solutions
3. Useful formulas/ conversions **$P_{total} = P_1 + P_2 + P_3$**	

Recall

1. **Re-arrange the combined gas law for T2**

1. **Why must all temperatures be converted to before solving gas law problems?**

2. **A sample of hydrogen gas is collected over water at 14.0 (P_{H2O} = 1.6 kPa). The pressure of the resultant mixture is 117.0 kPa. What is the pressure that is exerted by the dry hydrogen alone?**